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Stratigraphic Sequence and Basin development of the Mishrif Formation in Selected Oil fields in the Mesopotamian Zone, Southeastern Iraq

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***Abstract*— *The Mishrif Formation represents an important succession in the southern Iraq and has extensive distribution in the Middle East. The present study is focused upon the stratigraphic sequence and basin development of Mishrif Formation in three important oil fields in the Mesopotamian Zone of Iraq are:- Halfaya oil field (Hf-1, Hf-272, Hf-316), Noor oil field (No-1) and Buzurgan oil field (Bu-2, Bu-3, Bu-4).*

There are several types of microfacies were recognized in the succession of the Mishrif Formation. Their characteristic grain types and depositional texture enabled the recognition of six facies associations (depositional environments) were distinguished in this Formation, they are: Basinal, Slope, Shoal, Biostorm, Back Shoal (restricted) and Lagoon associations facies.

The microfacies analysis and reconstructed the paleoenvironments of the Cenomanian-Early Turonian basin in the studied area; there are three stages of the deposition: -

First stage:- during this stage the basin of Rumaila Formation was continued to deposition the lower part of Mishrif within the basinal environment. The end of this basin (Rumaila basin) marked by appeared the open marine associated facies to the northwest basin which represent the mfs surface. The Highstand system distinguished by sequential the open sea facies to the shoal facies and biostorm. The first stage was finished by widespread of shoal facies in all studied area to marked a sequence boundary type II (prograde stage A).

Second stage:- is represented by the developed the basin from the shoal to biostorm dominated facies with slow sea level rise. The presence of the open marine associated facies within the biostorm-shoal sequence marked the mfs surface. The final step of this stage was shown the shallowing up-ward by appeared the lagoon/restricted association facies overlying the biostorm. At the end of this period, the lagoon/restricted facies were spread in the studied area to mark the prograde stage B as sequence boundary type II.

Third stage:- the sea level was raised from the northwest direction as open sea association facies, while to the southeast the biostorme and shoal facies was dominated. The first appeared for the shoal facies upon the open sea facies marked the mfs surface to start the final highstand deposition within the restricted and biostorm/shoal facies. This stage is represent the prograde stage C for the Mishrif Formation, where the deposition has ended to mark the unconformable surface (SBI) with Khasib Formation.

Keywords*— *Stratigraphic Sequence, Basin development, Mishrif Formation and Mesopotamian Zone.

I. INTRODUCTION

The Mishrif Formation represents an important succession in the southern Iraq and has extensive distribution in the Middle East. The Mishrif Formation is deposited during Cenomanian-Early Turonian cycle as a part of the Wasia Group (Jassim and Goff, 2006). The Mishrif Formation in central Iraq reflects the continuous deposition of shallow marine carbonates. In central and southern Iraq, the Formation is represented in many oil field such as, Buzergan, Amara, Halfaya, Majnoon, Rumaila, West Qurna, and Nasiriya as well as other oil fields (Aqrawi et al., 2010).

The aim of this study is interpreted the stratigraphic sequence and basin development of the Mishrif Formation in the three important oil fields in the south of Iraq are:- Halfaya oil field (Hf-1, Hf-272, Hf-316), Noor oil field (No-1) and Buzurgan oil field (Bu-2, Bu-3, Bu-4).

The Halfaya field is located south of Iraq in Missan province, 35 kilometers southeast Amara city (Fig.1). The structure, which is composed of two domes runs along a NW-SE direction and gentle elongated anticline about 38km long and 12km wide. The field comprises a main body of the anticline with a length of 31km, and it extends in NW direction.

The Buzurgan field is located South of Iraq in Missan province. Buzurgan is situated near the Iraq-Iran border, about 300 km Southeast of Baghdad and 40 km Northeast of Amara city . The structure, which is composed of two domes runs along a NW-SE direction (Fig. 1) .

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Noor oil field is located to the southeast of Iraq about 15 km north east Amara city, Missan govemorate (Fig.1). The field is NW- SE trending anticline, and is about 18.9 km long and 5.9 Km wide.

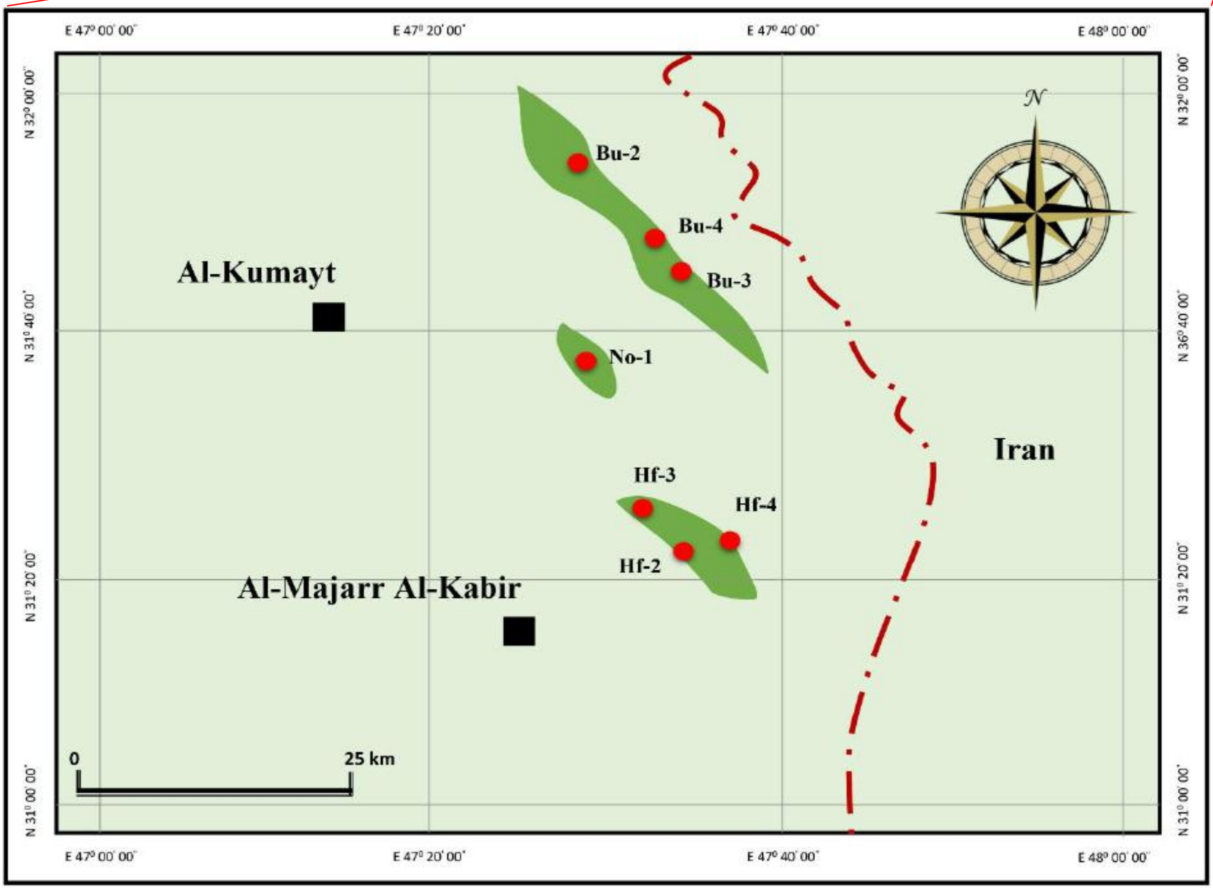

Fig.1: location map of studied area

II. STRATIGRAPHY

The lower boundary of Mishrif formation represents the change from basinal Rumaila Formation to shallow open marine facies as a conformable surface (Aqrawi et al. 2010). The upper boundary with the Khassib Formation is truncated by an unconformity surface separating the Middle from Late Cretaceous. The equivalent formations of the Mishrif Formation are Gir-bir formation in the North and the Balambo formation of the deeper eastern and intrabasinal part of the same basin of the Dokan Formation (Aqrawi et al. 2010) (Fig.2). The top Mishrif truncation forms the AP9/AP8 megasequence boundary at ~92 Million years (Sharland et al. 2001). The Rumaila/Mishrif High Stand System Tract represents the 3rd order K140 genetic sequence which is driven by both eustacy and subsidence (Aqrawi et al. 2010). The Mishrif is considered to be an overall progradational marine shelf sequence. Following the deposition of the transgressive shales and marly limestones of the Ahmadi and Rumaila Formations, rudist reefs and other related build-ups represented the deposition of the Mishrif Formation (Jassim and Goff, 2006).

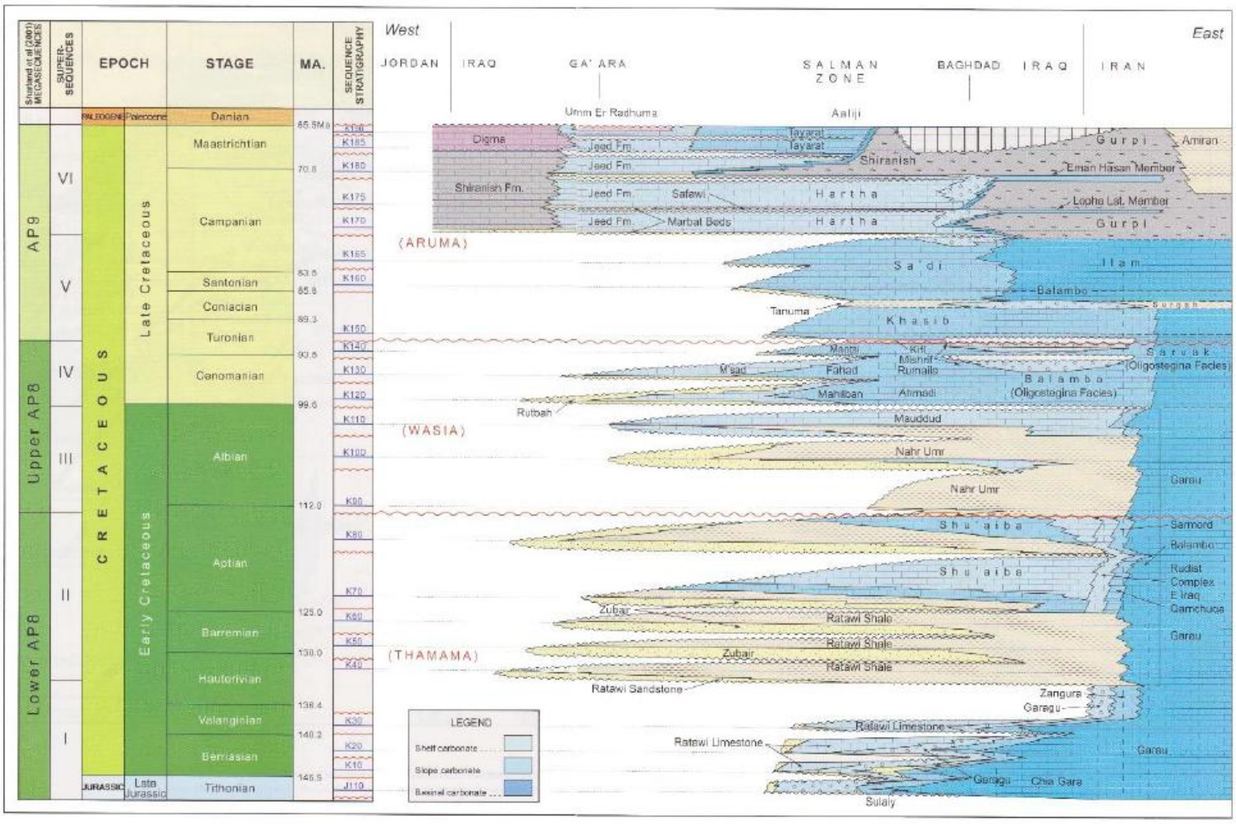

Fig.2: stratigraphic cross section of the cretaceous succession in Iraq (Aqrawi et al. 2010)

III. PALEOENVIRONMENTS AND MICROFACIES

Carbonate depositional textures of microfacies were described following the classification of Dunham (1962), and rudist-bearing facies were classified according to Embry and Klovan's classification (1971). The microfacies were compared with the models of standard microfacies and depositional environment belts of carbonates proposed by Wilson (1975) and Flugel (1982).

Facies associated with (Basin Environment): Recognized wackestone dominated "shallower sub-basinal" and mudstone-dominated "sub-basinal" sub-facies. The Facies analysis for the studied succession shows that environment is represented by the Hedbergella and Oligostegina mudstone-wackstone (Plt-1A) were founded as well as from logs analyses for wells mentioned in (Figs. 2-8) that show high gamma ray.

Facies associated with (Slope Environment): This facies association represents one of the most common facies in the Mishrif carbonates in the study area. It consists mainly of bioclastic or foraminiferal bioclastic wackstones and packstones. Other important fossils included in this facies association are benthonic foraminifera (Plt. 1-B), Calcareous algae, Coral, Echinoderms, sponge spicules, and Molluscs. It reflects low gamma ray and high porosity and the pore systems appear to be interconnected and good reservoir quality is envisaged.

Facies associated with (Shoal Environment)

This association is made up of very coarse-grained, shelly bioclastic rudstone and floatstone containing a more diverse intact fauna than lithofacies association with shoal environment, dominated by radiolitid and caprinid rudists as (Plt. 1-C).It is characterized by low gamma ray

Facies associated with (Rudist Biostrome Environment)

According to (AlKhersan, 1975; Aqrawi et al., 1998 in Aqrawi et al., 2010) three sub-facies are recognized (rudist packstones, rudist grainstones and rudist rudstones), distinguished by the relative content of micrite and the coarseness of the rudist-derived material as in (Plt. 1-D).

Facies associated with (Back Shoal Environment)

Thin to medium-bedded, fine to very coarse grained bioclastic packstone, wackestone, and grainstone characterize this association. It consists of packstone microfacies containing benthic foraminifera mainly Miliolid sp (Plt. 1-E). Back shoal facies association is characterized by low gamma ray (Figs. 3 - 9). This lithofacies probably has moderate reservoir quality.

Facies associated with (Lagoon Environment): This facies association comprises benthonic foraminiferal wackestone microfacies and peloidal wackestone microfacies (Plt. 1-F).The lagoon environment dominates

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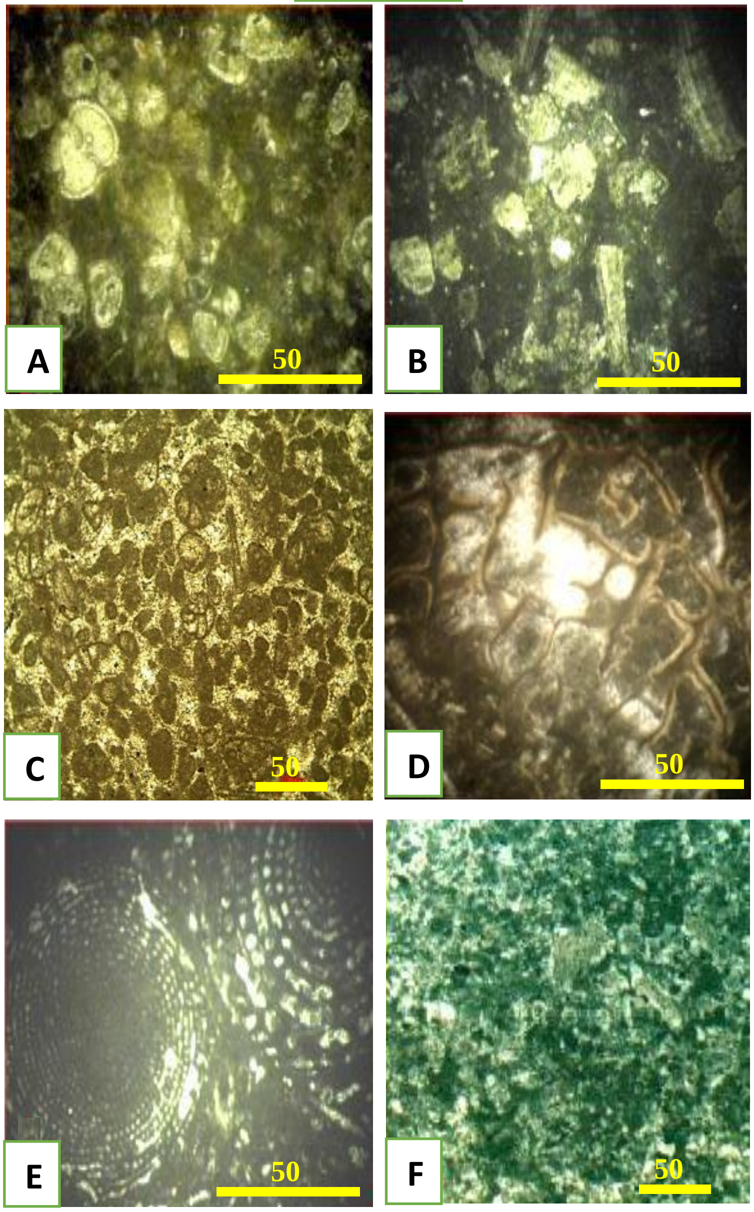
into the upper part of Mishrif succession below the upper unconformity surface that separates the Mishrif and overlying Khasib Formation, in addition to its dominance into the middle part of the Mishrif succession. These units are characterized by high gamma ray values and low porosity.

• **Buzurgan oil field:** Five microfacies were distinguished depends previous studies (Reulet , 1982), each of which represents a distinct depositional environment, and these were: (1) Deep marine, (2) open marine, (3) Rudist Biostrome, (4) Shoal, and (5) Lagoon (Dhihny,1998). The vertical stacking of these microfacies with their descriptions in the study wells are shown in figures (3,4 and 5).

• **Halfaya oil field**: Six main carbonate depositional microfacies, each of which represents a distinct depositional environment, and these were: (1) Basinal, (2) slope, (3) Shoal, (4) Rudist Biostrome, (5) Back shoal, and (6) Lagoon. The standard microfacies models and depositional environment belts of carbonates proposed by (Burchette, 1993) are shown in Figure (6, 7, and 8).

• **Noor oil field:** Six main paleoenviromnents are distinguished within Mishrif Formation according to facies analysis that has been studied. These six environments are: basin, slope, rudist biostrome, shoal, back shoal and lagoon. The essential oil bearing facies are included within the rudist and shoal environments and to some extent within the back shoal environment (Fig. 9).

Plate-1



(A) Hedbergella in Bioclastic Wackestones, HF-1, 3184 m.
(B) Rudist fragments, Biocasstic Grainston, HF-1, 2892m.
(c) Hedbergella in Bioclastic Wackestones, No1-1, 3400 m.
(D) Coral, Bioclastic Grainstone, HF-1, 2988 m.
(E) Cisalveolina in foraminiferal, bioclastic packstone, Hf-1, 2908.60 m.
(F) Pelloids and Miliolid in pelloidal packstones Hf-1, 2905m.

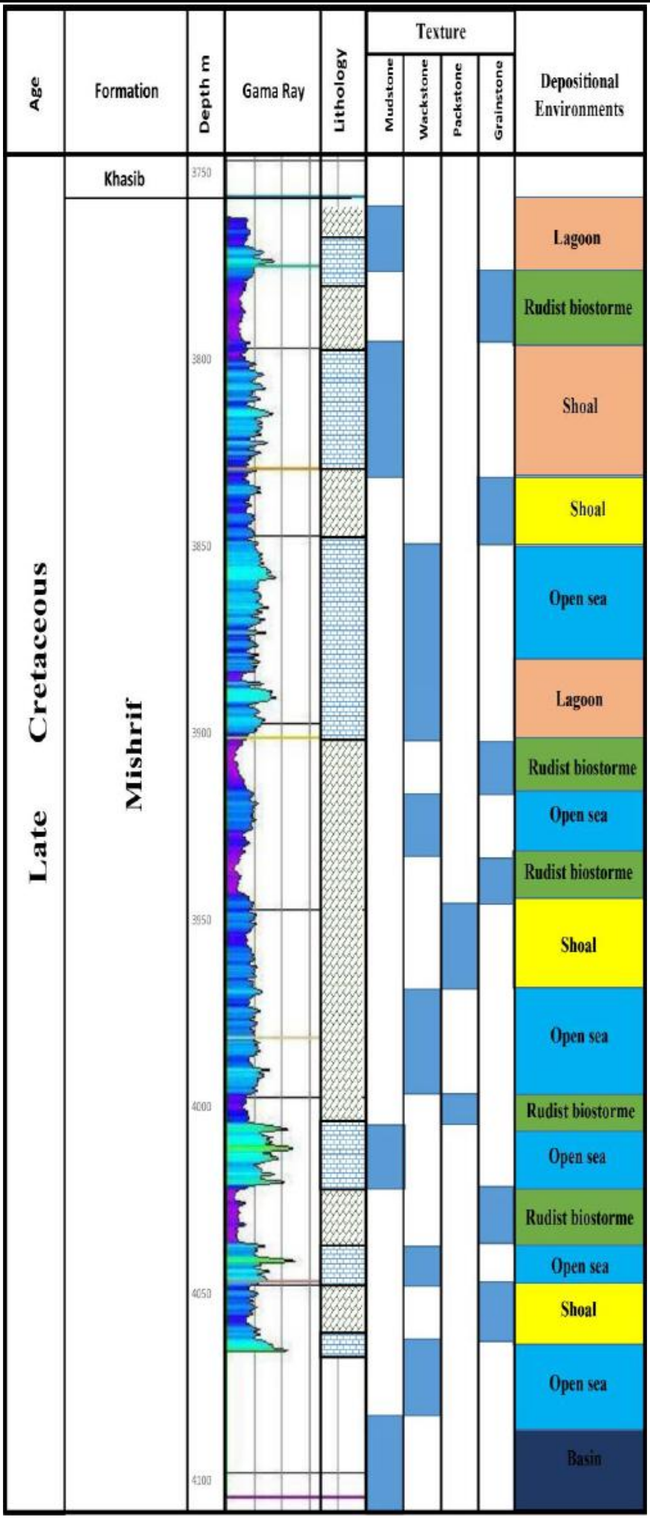


Fig. 3: Stratigraphic column of Mishrif Formation in Bu-2.

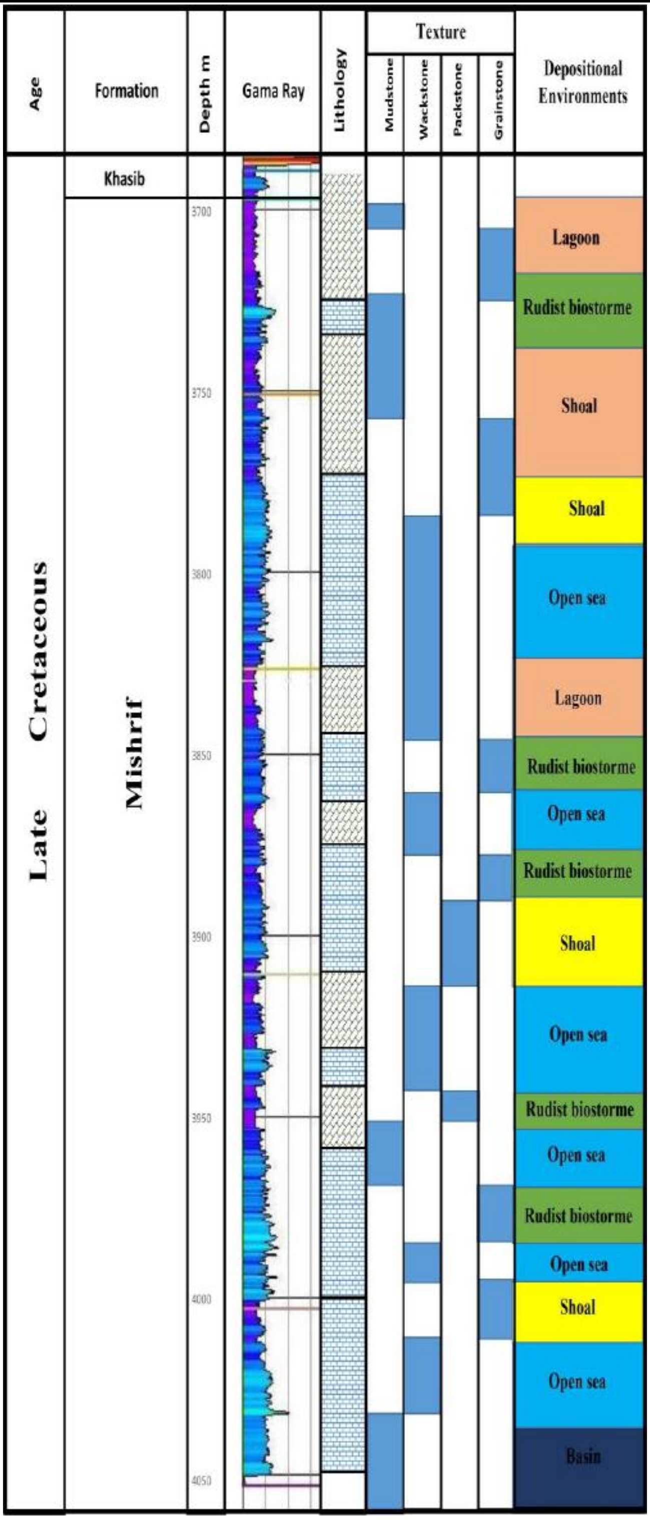


Fig. 4: Stratigraphic column of Mishrif Formation in Bu-3

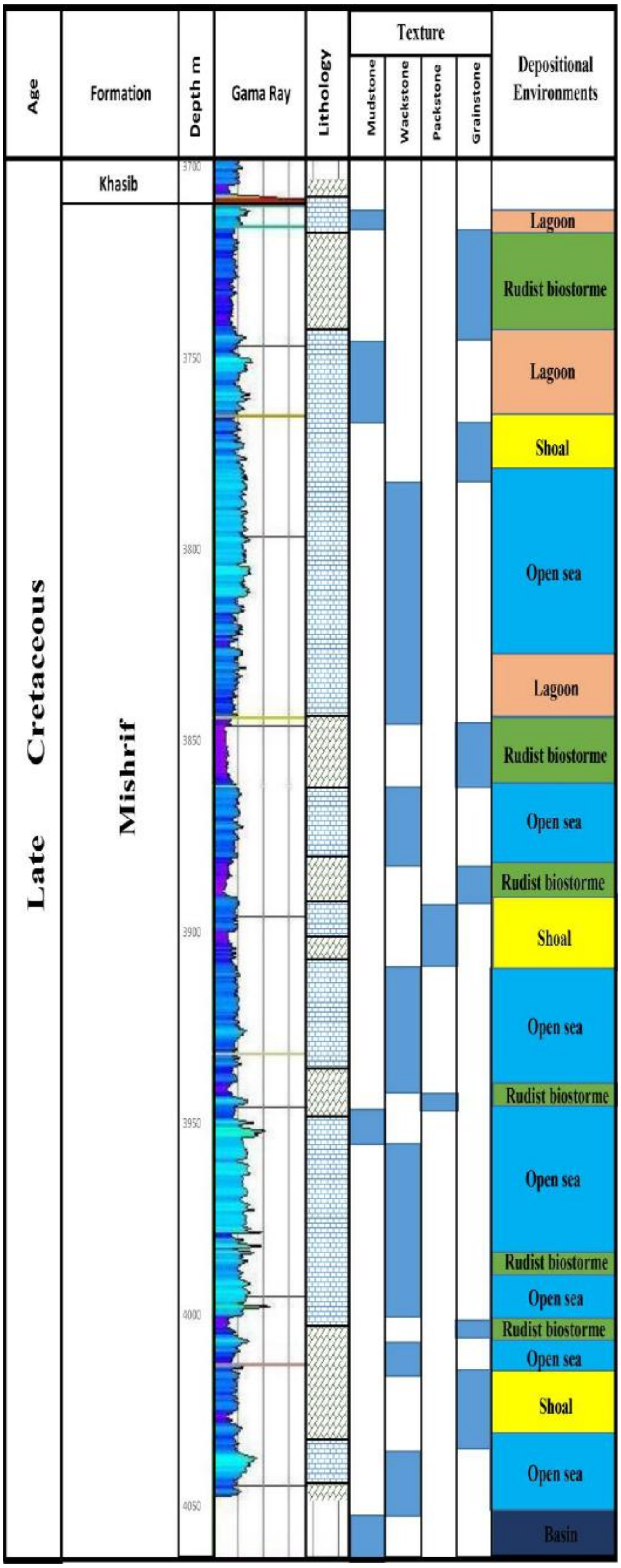


Fig. 5: Stratigraphic column of Mishrif formation in Bu-4

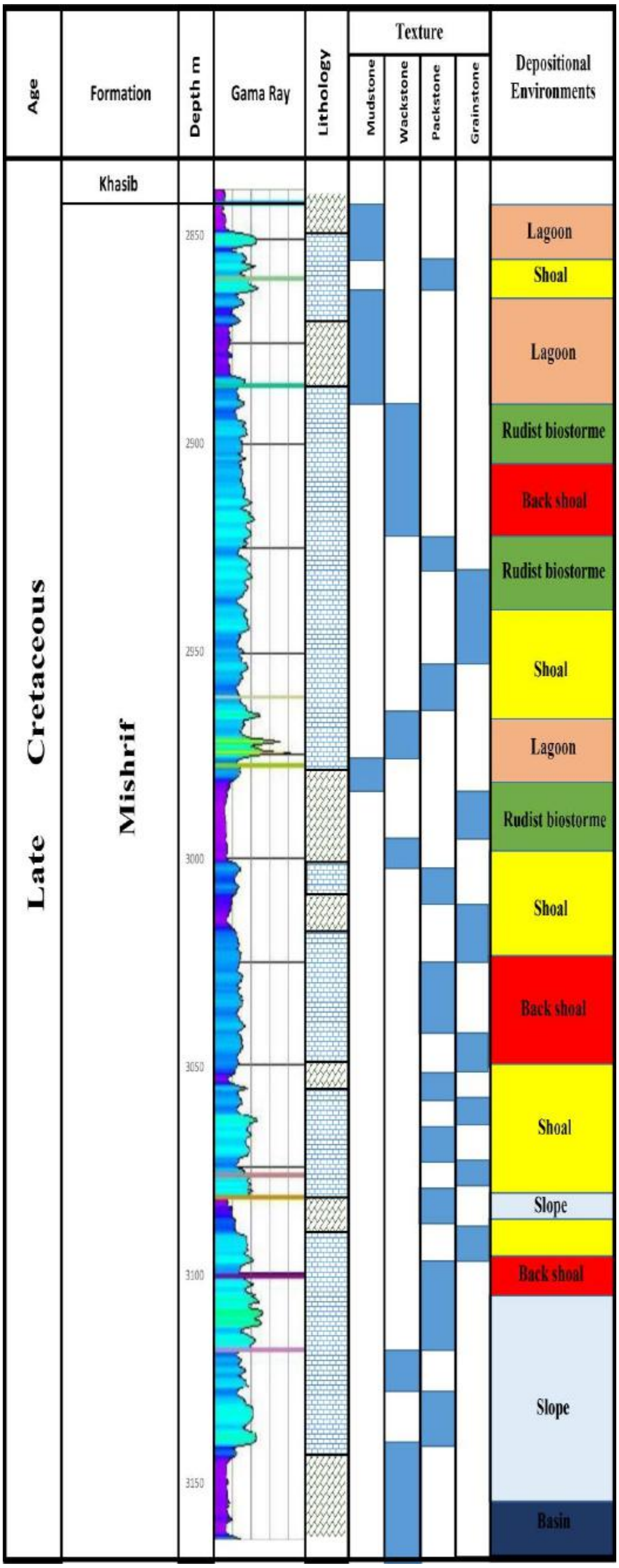


Fig.6: Stratigraphic column of Mishrif formation in Hf-1 .

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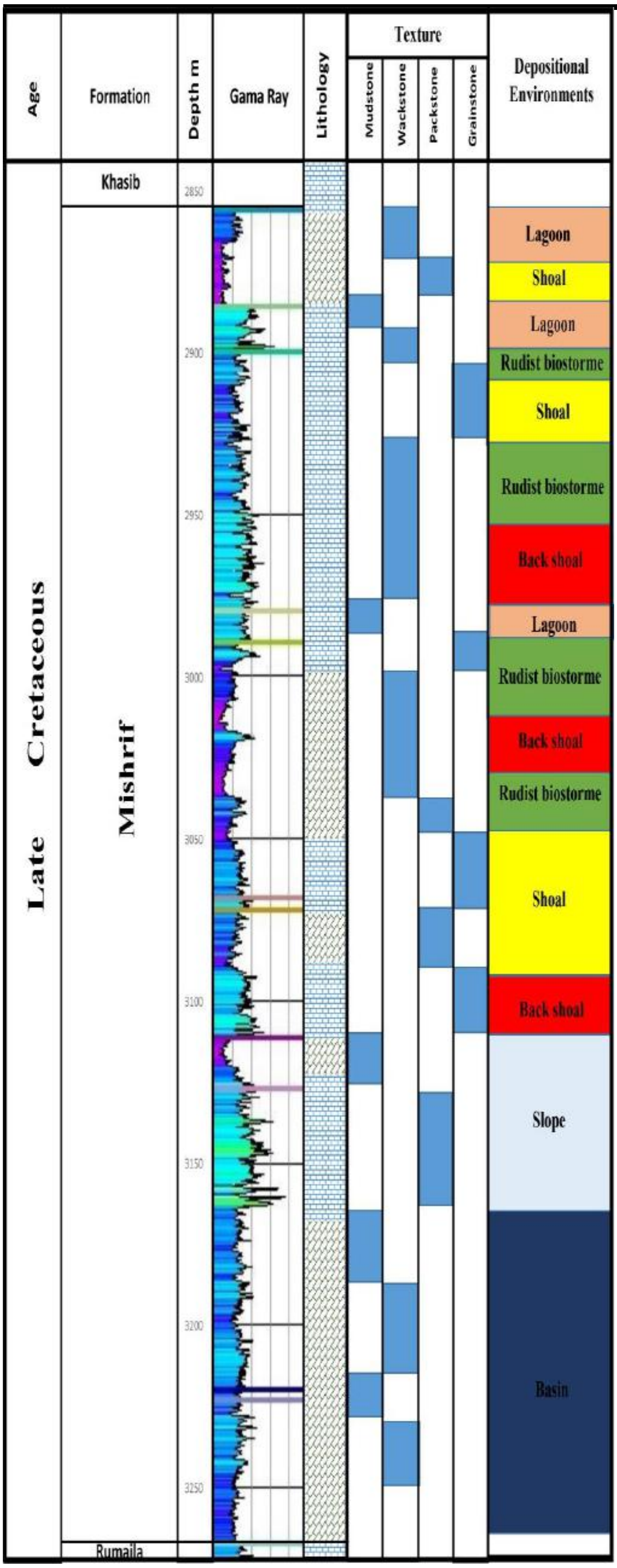

Fig. 7: Stratigraphic column of Mishrif Formation in Hf-272 .

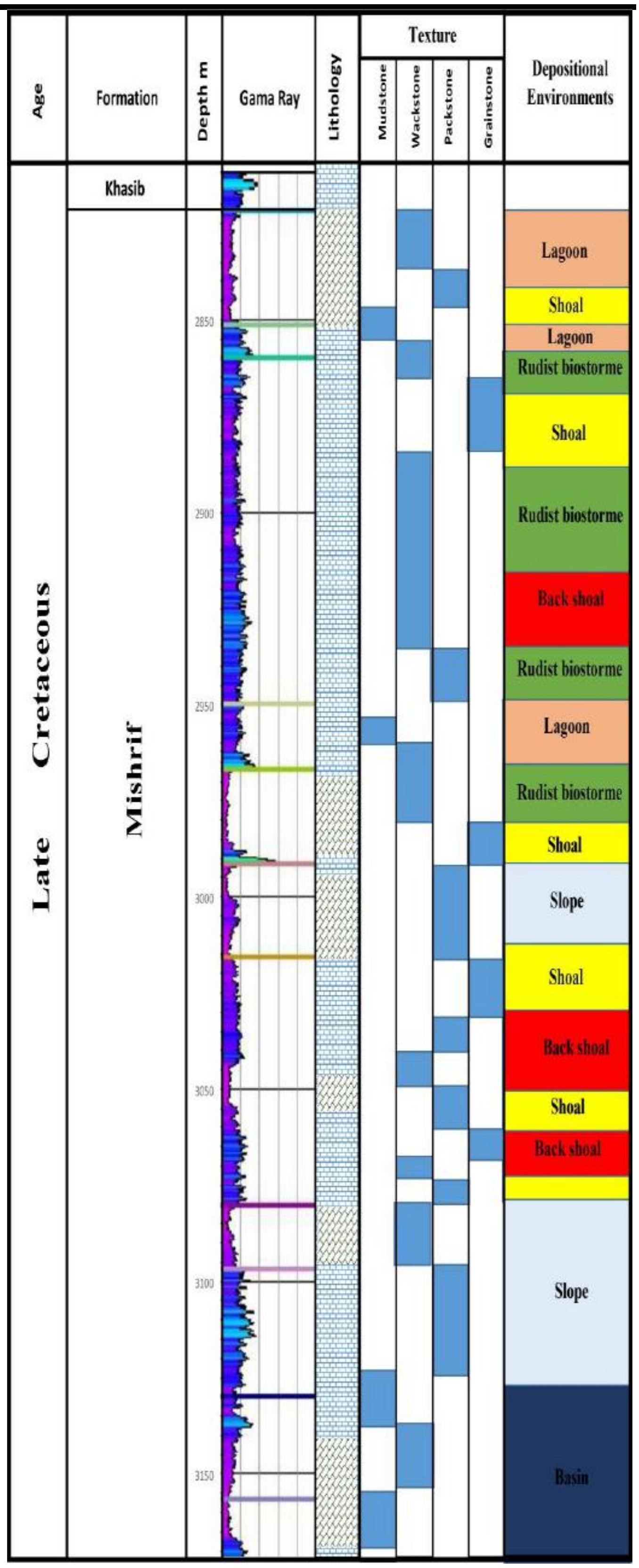

Fig. 8: Stratigraphic column of Mishrif formation in Hf-316.

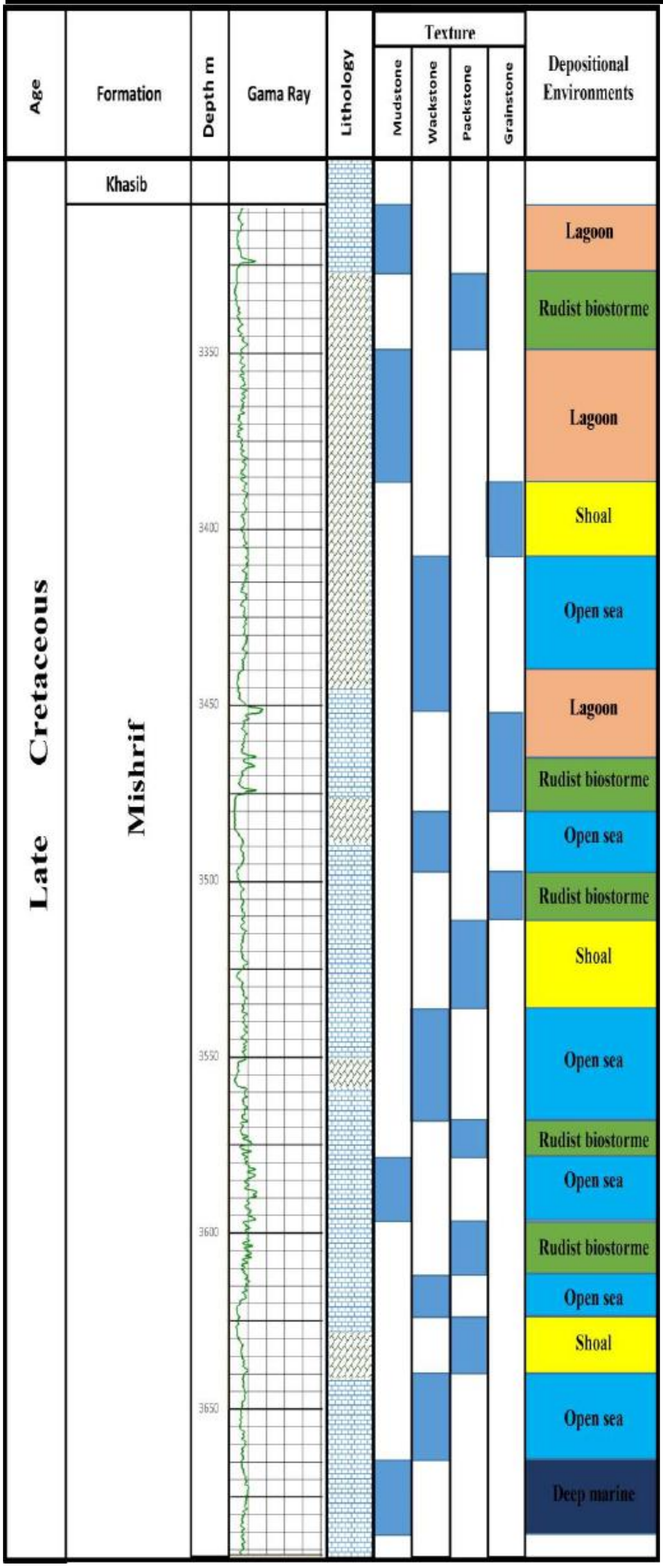

Fig. 9: Stratigraphic column of Mishrif Formation in No-1.

IV. STRATIGRAPHIC DEVELOPMENT

Sequence-stratigraphic correlation of the Mishrif Formation in the studied oil fields showing three stages of basin development during the Cenomanian-Early Turonian cycle:-

First stage:- during this stage the basin of Rumaila Formation was continued to deposition the lower part of Mishrif within the basinal environment. The end of this basin (Rumaila basin) marked by appeared the open marine associated facies to the northwest basin which represent the mfs surface. The Highstand system distinguished by sequential the open sea facies to the shoal facies and biostorm. The first stage was finished by widespread of shoal facies in all studied area to marked a sequence boundary type II (prograde stage A).

Second stage:- is represented by the developed the basin from the shoal to biostorm dominated facies with slow sea level rise. The presence of the open marine associated facies within the biostorm-shoal sequence marked the mfs surface. The final step of this stage was shown the shallowing up-ward by appeared the lagoon/restricted association facies overlying the biostorm. At the end of this period, the lagoon/restricted facies were spread in the studied area to mark the prograde stage B as sequence boundary type II.

Third stage:- the sea level was raised from the northwest direction as open sea association facies, while to the southeast the biostorme and shoal facies was dominated. The first appeared for the shoal facies upon the open sea facies marked the mfs surface to start the final highstand deposition within the restricted and biostorm/shoal facies. This stage is represent the prograde stage C for the Mishrif Formation, where the deposition has ended to mark the unconformable surface (SBI) with Khasib Formation.

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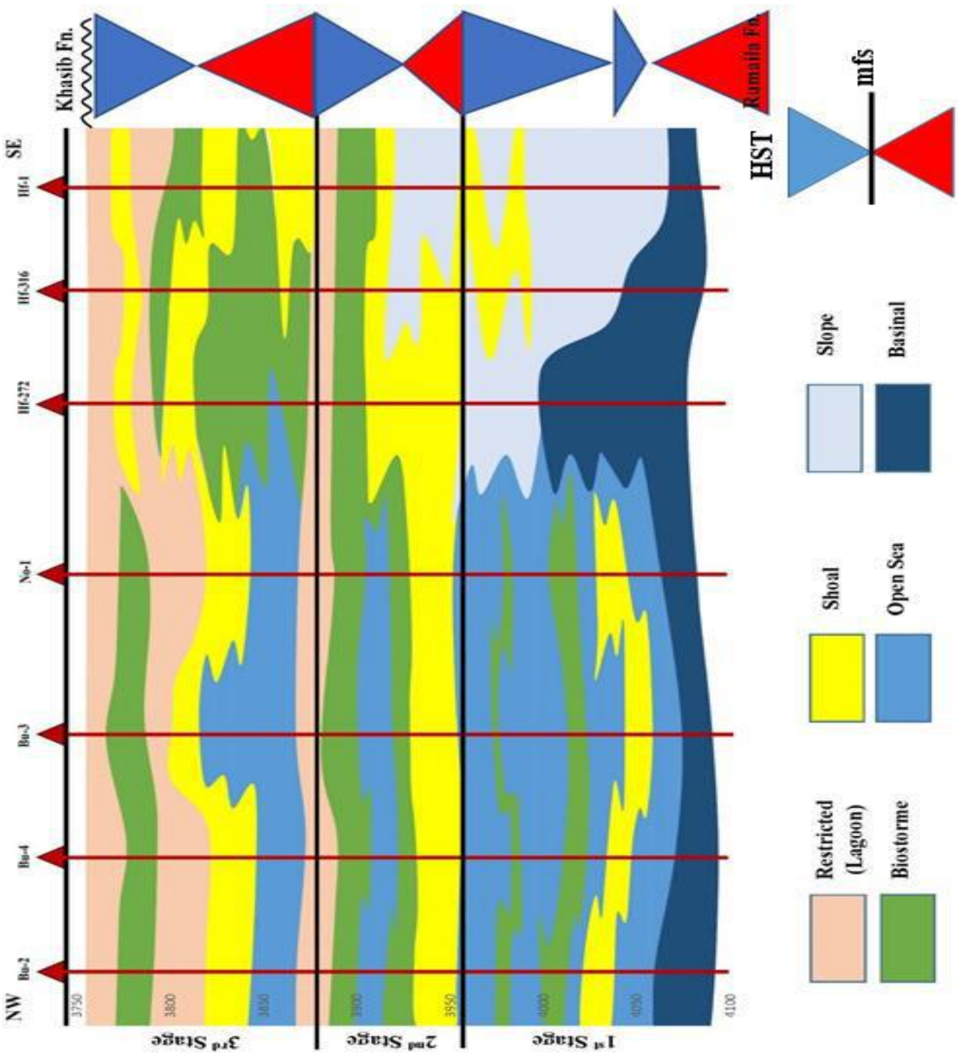

Fig. 10: Facies distribution and stratigraphic cross section of Mishrif Formation in studied area.

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